

WHAT IS CLAIMED IS:

1. A thermal barrier coating for an underlying metal substrate, which comprises:
 1. an inner layer nearest to and overlaying the metal substrate and comprising ceramic thermal barrier coating material; and
 2. a protective outer layer adjacent to and overlaying the inner layer and having an exposed surface, the outer layer having a thickness up to about 5 mils and sufficient to impart impact and erosion resistance to the thermal barrier coating, and comprising a zirconia-containing ceramic composition having a c/a ratio of the zirconia lattice in the range of from about 1.011 to about 1.016 and stabilized in the tetragonal phase by a stabilizing amount of a stabilizing metal oxide selected from the group consisting of yttria, calcia, ceria, scandia, magnesia, india, ytterbia and mixtures thereof.
2. The coating of claim 1 wherein the outer layer has a thickness in the range of from about 0.5 to about 2 mils.
3. The coating of claim 2 wherein the outer layer comprises from about 93 to about 96 wt. % zirconia and from about 4 to about 7 wt. % stabilizing metal oxide.
4. The coating of claim 3 wherein the c/a ratio is in the range of from about 1.013 to about 1.015.
5. The coating of claim 4 wherein the outer layer comprises from about 93.5 to about 95.5 wt. % zirconia and from about 4.5 to about 6.5 wt. % yttria as the stabilizing metal oxide.
6. The coating of claim 3 wherein the outer layer has a fraction of porosity of about 0.20 or less.

7. The coating of claim 6 wherein the outer layer has a fraction of porosity of about 0.15 or less.
8. The coating of claim 6 wherein the outer layer has a fraction of porosity in the range of from about 0.10 to about 0.20.
9. The coating of claim 2 wherein the outer layer comprises from about 2 to about 7 wt. % hafnia.
10. The coating of claim 9 wherein the outer layer comprises from about 4 to about 6 wt. % hafnia.
11. The coating of claim 2 wherein the outer layer comprises from about 0.3 to about 0.5 wt. % of a metal oxide selected from the group consisting of lanthana, neodymia, gadolinia and mixtures thereof.
12. A thermally protected article, which comprises:
 - A. a metal substrate; and
 - B. a thermal barrier coating comprising:
 1. an inner layer nearest to and overlaying the metal substrate and comprising ceramic thermal barrier coating material; and
 2. a protective outer layer adjacent to and overlaying the inner layer and having an exposed surface, the outer layer having a thickness up to about 5 mils and sufficient to impart impact and erosion resistance to the thermal barrier coating, and comprising a zirconia-containing ceramic composition having a c/a ratio of the zirconia lattice in the range of from about 1.011 to about 1.016 and stabilized in the tetragonal phase by a stabilizing amount of a stabilizing metal oxide selected from the group consisting of yttria, calcia, ceria, scandia, magnesia, india, ytterbia and mixtures thereof.

13. The article of claim 12 which further comprises a bond coat layer adjacent to and overlaying the metal substrate and wherein the inner layer is adjacent to and overlies the bond coat layer.
14. The article of claim 13 wherein the thermal barrier coating has a thickness of from about 1 to about 100 mils.
15. The article of claim 14 wherein the outer layer has a thickness in the range of from about 0.5 to about 2 mils.
16. The article of claim 15 wherein the c/a ratio is in the range of from about 1.013 to about 1.015.
17. The article of claim 16 wherein the outer layer comprises from about 93.5 to about 95.5 wt. % zirconia and from about 4.5 to about 6.5 wt. % yttria as the stabilizing metal oxide.
18. The article of claim 17 wherein the outer layer has a fraction of porosity of about 0.20 or less.
19. The article of claim 18 wherein the outer layer has a fraction of porosity of about 0.15 or less.
20. The article of claim 19 wherein the outer layer has a fraction of porosity in the range of from about 0.10 to about 0.20.
21. The article of claim 20 wherein the outer layer comprises from about 2 to about 7 wt. % hafnia.
22. The article of claim 21 wherein the outer layer comprises from about 0.3 to about 0.5 wt. % of a metal oxide selected from the group consisting of lanthana, neodymia, gadolinia and mixtures thereof.

23. The article of claim 14 which is a turbine engine component.
24. The article of claim 23 which is a turbine shroud and wherein the thermal barrier coating has a thickness of from about 30 to about 70 mils.
25. The article of claim 23 which is a turbine airfoil and wherein the thermal barrier coating has a thickness of from about 3 to about 30 mils.
26. A method for preparing a thermal barrier coating for an underlying metal substrate, the method comprising the steps of:
 1. forming an inner layer overlaying the metal substrate, the inner layer comprising a ceramic thermal barrier coating material;
 2. forming on the inner layer a protective outer layer having an exposed surface and a thickness up to about 5 mils and sufficient to impart impact and erosion resistance to the thermal barrier coating, and comprising a zirconia-containing ceramic composition having a c/a ratio of the zirconia lattice in the range of from about 1.011 to about 1.016 and stabilized in the tetragonal phase by a stabilizing amount of a stabilizing metal oxide selected from the group consisting of yttria, calcia, ceria, scandia, magnesia, india, ytterbia and mixtures thereof.
27. The method of claim 26 wherein a bond coat layer is adjacent to and overlies the metal substrate and wherein the inner layer is formed on the bond coat layer.
28. The method of claim 27 wherein the inner and outer layers are formed by physical vapor deposition to form a thermal barrier coating having a strain-tolerant columnar structure.
29. The method of claim 26 wherein the thermal barrier coating formed has a thickness of from about 1 to about 100 mils.

30. The method of claim 29 wherein the outer layer formed has a thickness in the range of from about 0.5 to about 2 mils.
31. The method of claim 30 wherein the outer layer formed has a c/a ratio is in the range of from about 1.013 to about 1.015.
32. The method of claim 31 wherein the outer layer formed comprises from about 93.5 to about 95.5 wt. % zirconia and from about 4.5 to about 6.5 wt. % yttria as the stabilizing metal oxide.
33. The method of claim 31 wherein the outer layer formed has a fraction of porosity in the range of from about 0.10 to about 0.20.